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Synthesis of Potash Alum from Waste Aluminium Foil

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Abstract: *The study was done to synthesize the Potash alum from waste Aluminium foil. Potash alum IUPAC name is Aluminium potassium sulphate dodecahydrate and commonly referred to as fitkari. The used aluminium foil was washed properly and was dissolved in potassium hydroxide to form a complex aluminate. It was then filtered and sulphuric acid was added to aluminate, placed in a water bath and again filtered to obtain potash alum. The analysis of synthesized alum confirms the presence of potassium, aluminium, sulphate and water of hydration with a melting point of 91.5 degrees Celcius. The product yield was 10.58%. The conductivity and TDS of soil sample treated with synthesized alum were 1.579 ms and 1.026 ppt with a comparison with commercial alum 6.73 ms and 4.37 ppt respectively.*

Keywords: *Potash alum, aluminium foil, aluminate, TDS.*

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Introduction:

Aluminium is the third most plentiful element and the most abundant metal in the earth's crust, with a number of high-grade natural bauxite resources (Ugwekar and Lakhawat, 2012). High tensile strength, low density and resistance to corrosion makes aluminium suitable for the manufacturing of automobiles, aeroplanes, aluminium cans, aluminium foil and many more.

As landfills across the globe continue to be a final resting place for aluminium beverages cans, foils etc, which when incinerated, contaminates the air with toxic compounds and take up to 500 years to fully decompose.

Aluminium is an infinitely recyclable material and it takes 95% less energy to recycle it than to produce primary aluminium. One such way to recycle aluminium is to convert it into potash alum form. Potash alum has wide application in wastewater treatment plants, the food industry, textile and many more.

Aluminium is clearly a valuable material with a gigantic environmental footprint and social cost.

Materials and Methods:

250 ml beaker, 100 ml measuring flask, water bath, china dish, magnetic stirrer, test tubes, TDS Meter.

Synthesis of potash alum: 0.500 gram of waste aluminium foil was taken in a 250 ml beaker and washed properly and then cut in small pieces. 25 ml of 1.4 M potassium hydroxide solution was added slowly and carefully in the beaker. The beaker was placed on a magnetic stirrer and all the aluminium foil was allowed to dissolve. The beaker was removed from the magnetic stirrer and the solution was allowed to cool down. The solution was filtered into another 250 ml beaker. Carefully and slowly added 5 ml of 9M sulphuric acid to the filtered solution. The beaker was placed in a water bath with ice and was left for two days. The solution was filtered in a Buchner funnel and 15 ml of cold 95% ethanol solution was used to wash the residual sulphuric acid from alum crystals. The obtained yield of potash alum was left to dry for 1 day. After one day its melting point was recorded.

The general reaction that occurs is as follows:

$$2Al(s) + 2KOH(aq) + 4H_2SO_4(aq) + 22H_2O(l) \rightarrow 2KAl(SO_4)_2 + 24H_2O(s) + 3H_2(g)$$

Calculation of percent yield of alum: To determine the percent yield of a product in a chemical reaction we need to know the amount of all reactants used, the number of products, and the balanced chemical equation. We first determine the limiting reagent and then theoretical yield of the product. The percent yield is then simply the actual amount of product obtained divided by theoretical yield multiplied by hundred (Curdy et.al., 2014).

A balanced chemical reaction is:

$$2Al(s)+2KOH(aq)+12H_2O(l)+4H_2SO_4(aq)\rightarrow 2KAl(SO_4)_2 + 24H_2O\ (s)+ 3H_2(g)$$

Here Al is the limiting reagent.

0.500 grams of Aluminium was taken and 0.90 gram of potash alum was obtained.

Moles of Al in 0.500 gram of Al is

0.5 g of Al (1mole Al) / 26.982g Al = 0.018 mole of Al

Moles of Al was converted to moles of alum using stoichiometric factor from the balanced chemical equation.

0.018 mole Al (2mole alum) / (2mole Al) = 0.018-mole potash alum.

The mass of potash alum (in grams) was converted from moles of potash alum. This is theoretical yield.

0.018 mole potash alum (474.39g potash alum)/(1mole potash alum) = 8.5 gram of potash alum.

Determination of percent yield : 0.90gram × 8.5 gram = 10.58%

Qualitative Analysis of potash alum: Sulphate Test – A few crystals of potash alum were placed in a test tube and distilled water was added dropwise while stirring until the potash alum dissolves completely. Then two drops of 0.5M $BaCl_2$ solution was added.

Potassium flame test- The platinum wire was heated in flame to remove impurities. After cleaning the needle, with conc. HCl a little amount of potash alum was gently scooped onto the end of platinum wire. It was placed in the flame, and heated until crystals began to melt and form solid glow.

Aluminium detection test- Taken potash alum in a test tube and added distilled water to dissolve it. Then added ammonium chloride followed by an excess of ammonium hydroxide.

Quantitative determination of water of hydration: Alum sample was in powder form. The crucible was cleaned by placing a few drops of 1M NH_3 solution in the empty crucible and scrubbed with a paper towel. The crucible was rinsed with distilled water and the empty crucible was placed on a porcelain triangle supported by a ring stand. With the majority of the flame remaining below the bottom of the crucible, the crucible was heated until its bottom glowed red. After heating the flame was removed and the crucible was allowed to cool. The crucible and its cover were weighed. 0.20 gram of potash alum was placed in the crucible and the mass along with its cover was obtained again. The crucible was heated again with cover slightly ajar so that water vapour can escape. The crucible was heated until it glowed red. The flame was removed and the crucible was allowed to cool. The mass of the crucible with cover was recorded again.

Mass of crucible + cover = 48.42 g.

Mass of crucible + cover + potash alum = 48.62 g.

Mass of crucible + cover + anhydrous potash alum = 48.55g.

Mass of potash alum taken = 0.20 g.

Mass of water driven off by decomposition= 48.62 - 48.55 = 0.07.

The experimental percentage of water of hydration = 0.07/0.20 x 100 = 35%.

The theoretical percentage of water is; (12 x 18.02 g / 474.46 g) x 100 = 45.5%.

Application of potash alum: Soil sample was prepared by dissolving 25 g soil in 100 ml water and filtering it. The filtrate obtained was placed in a 100 ml measuring flask and distilled water was added up to the mark. The soil samples were taken in two test tubes and were labeled as A and B and its conductivity and TDS were measured. Synthesized potash alum was added in test tube A and commercial potash alum in test tube B and both were covered with rubber cork. The samples were left for three days. The conductivity and TDS of both the test tubes were measured again.

Results and Discussion:

For the formation of potash alum, the dissolution of Al(s) in aqueous KOH is a redox reaction. The Al metal is oxidized to aluminium with oxidation number +3 and hydrogen in KOH is reduced from an oxidation number +1 to 0 in hydrogen gas. The $[Al(OH)_4]^-$ ion is a complex ion called “aluminate”. The reaction between aluminate and sulphuric acid produces a thick white precipitate of aluminium hydroxide, as more acid is added, the precipitate dissolved. The solution at this point contains Al^{3+} ions, K^+ ions and $(SO4)^{2-}$ ions. The result of the production of potash alum from used aluminium foil, the mass of potash alum obtained was 0.90 gram. The melting point of potash alum was to be 91.05 degree celcius which shows that an alum crystal with 24 molecules of water and containing 45.5% of water when subjected to heat, it melts rapidly at 91.05 degree celcius.

The percent yield of synthesized potash alum was 10.58%. The low yields of potash alum was possibly due to the impurities present in the aluminium wastes as compared to the theoretical calculated yield of alum (CPCB, 2000).

Qualitative analysis test : Sulphate test gives a white precipitate which is insoluble in conc. HCl and nitric acid when reacted with barium chloride confirms the presence of sulphate ion in synthesized potash alum (Gitelman, 1988).

The potassium flame test gives lilac coloured flame which confirms the presence of potassium in synthesized potash alum.

The aluminium detection test gives gelatinous gel which confirms the presence of aluminium in synthesized potash alum.

Potash alum is a hydrate, which means that it is a compound that has water molecules trapped within the solid. The presence of water of crystallization was indicated here by the loss in the mass of potash alum crystals. One should expect that heating the alum will result in the decrease in weight of the alum corresponding to the loss of 12 molecules of water per unit of potash alum (Edzwald et. al., 2003). The experimental percentage of water of hydration is 35% and the theoretical percentage of water of hydration is 45.5%. The process by which the water of hydration is driven off is shown as:

$$KAl(SO_4)_2.12H_20\ (s) \rightarrow KAl(SO_4)_2(s)+12H_2O(g)$$

For the application of potash alum, the ability of potash alum to form coagulants in order to purify water containing impurities is shown. The higher efficiency to treat turbid water has made inorganic chemicals favourite coagulants (Pernitsky and Edzwald, 2003). Potash alum is one of the widely used coagulants in the water treatment industry. When added to water, Al ions hydrolyze rapidly and form a range of metal hydrolysis species. Upon hydrolysis aluminium hydroxide precipitate is formed, this precipitate sweeps the colloidal particles from the suspension and is called the sweep-floc coagulation. Since it does not involve any charge reversal this is more popularly used in water treatment. The application of potash alum is shown through its ability to purify water by the process of coagulation. Here conductivity and TDS (total dissolved solids) measurements of soil sample before and after the addition of potash alum is shown (Table 1). Here synthesized and commercial potash alum was taken for comparative study. The displayed value for TDS and conductivity was in milli semens for conductivity or in ppt (parts per trillion) range for TDS. The total dissolved solids concentration is the sum of cations and anions present in the water. TDS measurement is based on the electrical conductivity of water. It is calculated by converting the electrical conductivity by a factor of 0.5 to 1.0 times the electrical conductivity.

Table 1. TDS and conductivity determination of soil sample treated with synthesized and commercial potash alum

Sample	TDS	Conductivity
KCl	0.680 ppt	1 ms
Soil sample	0.1527 ppt	0.235 ms
A (synthesized potash alum)	1.026 ppt	1.579 ms
B (commercial alum)	4.37 ppt	6.73 ms

Conclusion:

From the present study, it can be conclude that aluminium has the potential of getting recycled many times without losing it's integrity. So instead of throwing waste aluminium foil in the dustbin (Banks and Kastin, 1989), potash alum can be made from it which can be further used in several sectors. One of those is its wide application in water purification system. In this study, 0.90 gram of synthesised potash alum from waste aluminium foil was obtained whose melting point was 91.05 degree celsius and percent yield was 10.58%. Then sulphate test, potassium flame test and aluminium detection test confirmed the presence of sulphate, potassium and aluminium respectively. The quantitative determination of water of hydration was found to be 35%. The application of potash alum was shown through it's ability to form coagulants in order to purify dirty water. The comparative study of synthesized and commercial potash alum in conductivity and TDS determination, showed that commercial potash alum is more efficient in TDS (total dissolved solids) determination than the synthesized potash alum with the value 4.37 ppt and 1.026 ppt respectively. It was also found that the commercial potash alum was more efficient in conductivity determination than the synthesized alum with the value 6.73 ms and 1.579 ms. Sequel to the results obtained from qualitative, quantitative analysis and coagulation action of synthesized potash alum, the chemical recovery method was found to be an efficient and effective way to recycle waste aluminium foil (Maiti, 2001).

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